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Distribution of prostheses position after primary total knee arthroplasty on dominant and non-dominant sides

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【Abstract】 Background To investigate the changes of prosthesis position after primary total knee arthroplasty (TKA) on the dominant and non-dominant sides. **Methods** A retrospective analysis was made of 132 patients (148 knees) who underwent primary TKA from December 2016 to December 2018 in our hospital. The patients were divided into dominant group (right side) and non-dominant group (left side) according to the position of the three right-handed surgeons. Total operation time, posterior distal femur angle (PDFA), posterior proximal tibia angle (PPTA), malposition rate of femoral prostheses in sagittal, postoperative hip-knee-ankle angle (HKA), mechanical lateral distal femoral angle (mLDFA), mechanical medial proximal tibial angle (mMPTA) were compared between the two groups. **Results** The mean total operation time was in dominant group was 111.8(111.8±26.9) and in non-dominant group was 113.7(113.7±26.1) ($P>0.05$). Postoperative sagittal alignment, the mean PDFA was 90.2(90.2±3.3°) in dominant group and 88.8(88.8±3.6°) in non-dominant group ($P<0.05$). The mean PPTA was 84.8(84.8±2.8°) in dominant group and 85.4(85.4±3.7°) in non-dominant group ($P>0.05$). The incidence of malposition of sagittal femoral prosthesis in dominant group was 6/76 (7.9%) and that in non-dominant was 15/72 (20.8%). There was a significant difference between the two groups ($\chi^2=5.083$, $P=0.024$). Postoperative coronal alignment, the mean angle of components placement was 2.1°±4.2° for HKA, 88.7°±2.7° for mLDFA, 89.5°±2.7° for mMPTA in dominant group and 1.6°±4.1° for HKA, 89.0°±2.8° for mLDFA, 89.9°±2.7° for mMPTA in non-dominant group, respectively. There were no significant difference between the two groups ($t=0.804$ $P=0.423$, $t=-0.564$ $P=0.574$, $t=-1.011$ $P=0.314$). **Conclusion** Our study suggests that surgeon handedness is likely to be one of factors that affect the sagittal placement of femoral component. Orthopaedic surgeons should be aware of the potential problems and consider taking extra precautions to mitigate the risk before performing surgery.

【Key words】 Arthroplasty, replacement, knee, Prosthesis component positioning, Hand dominance

Background

Total Knee Arthroplasty (TKA) is an effective method for the treatment of end-stage knee arthritis, and ensuring the accurate positioning and alignment of knee components has been considered associated with good stability and a lower rate of loosening^{1;2}. Most of studies focus on improving the accuracy of prosthesis placement including computer-assisted navigation systems, robotic-assisted systems, and patient-specific instrumentation during the past decade³.

But there are few studies about the influence of dominant side of the surgeon. Moloney et al.⁴ compared preoperative and postoperative radiographs of 244 patients with femoral neck or intertrochanteric fractures treated with sliding hip screws and found that 12 surgical failures occurred on the left. Pennington et al.'s⁵ study suggested that the surgeon's dominant hand had an influence on the position of the acetabular component. Another recent study has shown that right-handedness is a problem during the upper thoracic pedicle screw placement on the left side

by retrospectively reviewing 33 patients ⁶.

At present, it is still unknown whether the surgeon's dominant side and non-dominant side have influence on the position of the knee prosthesis. Even though computer-assisted navigation technology can obtain more accurate components alignment than conventional surgical techniques, there is no statistically significant difference in terms of clinical outcome ⁷. Moreover, the navigation systems are more expensive and the operation times are longer than conventional techniques. Conventional TKAs are still the main method for the treatment of end-stage knee arthritis. Thus, the purpose of this study was to investigate whether surgeons dominant side had any influence in primary TKA components alignment based on postoperative radiography. We hypothesize that the surgeon's dominant side has an influence on components placement and it is more accurate in dominant side than non-dominant side.

Methods

We prospectively followed up and retrospectively reviewed 531 consecutive patients (531 knees) who accepted primary total knee arthroplasties from May 2016 to December 2018.(Fig.1).The TKAs were performed by 3 surgeons(A, B, and C),who were defined as right-handers according to the Edinbuegh Handedness Inventory ⁸. The annual operation volume of surgeons were more than 50 TKAs/year ⁹. All patients were placed in the supine position, the surgeons performed the surgical procedure standing on the side of the operative extremity. We defined the right-handed surgeons performed the right knee replacement as the dominant side, and the left knee replacement performed by right-handed surgeons was defined as the non-dominant side.

All operations were performed through the medial incision of the knee joint and medial paraptellar approach, the patellofemoral joint was exposed after turning outward the patella, The distal femoral was cut using intramedullary rods and the proximal tibial using extramedullary alignment guides. A posterior reference point of the femur was used as a guide to determine the position of the femoral component in the sagittal plane. Cemented, posterior-stabilized TKAs were performed after use of a measured resection technique. The operation time was recorded from incision to skin closure. All patients stayed until the surgical suture was removed.

Patient demographics, diagnosis, degree of deformity, surgeon, side, prosthesis type, total operation time, complications were recorded. Radiographic analysis was performed on full-length standing anteroposterior radiograph of the lower extremity and adequate lateral radiographs using a picture archiving and communication system (PACS) measurement tools on the earliest acceptable postoperative images. Radiographs were measured by two independent observers who had no clinical contact with the patients.

The following angles were used for descriptive analysis of pre- and postoperative alignment: The hip-knee-ankle angle (HKA) was defined as the angle between the femoral mechanical axis and the mechanical axis of the tibia. The hip center was obtained using concentric Moose circles ¹⁰. The pre-operative center of knee was measured by the intersection of the midline between the tibial spines and the midline between the femoral condyles and tip of the tibia. The center of the ankle was determined as the midpoint of the talus. Postoperatively, the center of the knee was determined as the intersection of the midline in the middle of the poly-ethylene inlay and the midline between the condyles of the femoral prosthesis and the tip of the tibial prosthesis ¹¹. The HKA was defined to be normal between $\pm 3^\circ$ of the neutral alignment ^{12; 13}. The mechanical lateral distal femoral angle (mLDFA) was defined as the lateral angle between the mechanical axis

of the femur and the distal femoral articulate surface. The mechanical medial tibial angle (mMPTA) was defined as the medial angle between the mechanical of tibia and the proximal tibial joint line (Fig.2.1). The ideal postoperative angle was 90° ¹⁴.

The posterior distal femur angle (PDFA) was defined as the angle between the femoral posterior diaphyseal cortical bone and the distal femoral cut, The posterior proximal tibia angle (PPTA) was defined as the angle between the tangent to the posterior diaphyseal cortical bone and the tibial plateau. They were measured using published methods ¹⁴(Fig.2.2). The normal angle was 90° . In addition, the femoral component that was placed unevenly with the distal part of the native femur was defined as malposition of femoral component including over-flexed femoral prosthesis and femoral notch.

Statistical analysis

All data were analyzed using SPSS version 19.0 (IBM). Interobserver reliabilities were assessed by the interclass correlation coefficient (ICC). Univariate analysis was performed using parametric (Student t test) such as age, body mass index (BMI), HKA, mL DFA, mMPTA, PDFA, PPTA between dominant and non-dominant sides. Nominal categorical variables such as male were assessed using the Chi-square or Fisher exact test. A p value of <0.05 was considered statistically significant.

Result

A total of 132 patients (148 knees) were enrolled in this study. There were 25 males (27 knees) and 107 females (121 knees). The mean age was 67.3 years, BMI was 26.6 kg/m^2 , 72 were left side and 76 were right side. The main diagnosis was osteonecrosis of the knee osteoarthritis (92.6%, 137/148). The operations of surgeon A, B, and C were: 100 knees, 31 knees, and 17 knees, respectively. The majority type of implants involved were post-stabilized prostheses (Zimmer Nex Gen LPS) (31.8%, 47/148) (Table 1). There were no statistically significant differences in preoperative age, gender, BMI, and HKA between the dominant and non-dominant groups (Table 2).

The interclass coefficients for independent measurement by two observers of limb and knee alignment were reliable. The interobserver reliability was 0.87(95% confidence interval [CI] 0.83; 0.89) for preoperative HKA and 0.99(95%CI 0.9; 0.99) for postoperative HKA. The interobserver reliability was 0.98(95% CI 0.96; 0.98) for mL DFA and 0.98(95% CI 0.95; 0.98) for mMPTA. The interobserver reliability was 0.88(95% CI 0.83; 0.91) for PDFA and 0.87(95% CI 0.83; 0.90) for PPTA, respectively.

Postoperative coronal alignment

Analysis of HKA revealed a mean of 2.1 degrees on the dominant operated side and 1.6 degrees on the non-dominant side. Statistical analysis using Independent-Samples t-test showed this to be not significant ($P=0.423$). The mean mMPTA was 89.5 degrees on the dominant side and 89.9 degrees on the non-dominant side. The mean mL DFA was 88.7 degrees on the dominant side and 89.0 degrees on the non-dominant side. Independent-Sample t-test also found this to be not statistically significant ($P=0.314$, $P=0.574$ respectively) in terms of the postoperative coronal alignment of the components.

Postoperative sagittal alignment

The mean PDFA represented postoperative sagittal alignment of femoral component was on the dominant operated side and on the non-dominant side. The mean PDFA was $90.2(90.2^{\circ} \pm 3.3^{\circ})$ in dominant group and $88.8(88.8^{\circ} \pm 3.6^{\circ})$ in non-dominant group. There was statistically difference

in two groups ($P=0.015$). We further analyzed the proportion of the ideal position of the femoral prosthesis in the sagittal plane between the two sides and found the odds ratio of the dominant side was 72.4%(55/76), and the non-dominant group was 69.4%(50/72). The difference was not statistically significant ($\chi^2=0.153$, $P=0.695$) (Fig.3). The mean PPTA represented postoperative sagittal alignment of tibial component was on the dominant operated side and on the non-dominant side. The t-test showed this to be not significant ($P=0.278$) (Table 3).

The incidence of femoral notch was 1.3% in the dominant operated side and 9.7% in the non-dominant side. This difference approached but did not reach statistical significance ($\chi^2=3.598$, $P=0.058$). The incidence of over-flexed femoral prosthesis in the dominant side was 6.5%, and that in the non-dominant side was 11.1%. There was no significant difference between the two groups ($\chi^2=0.948$, $P=0.330$). But the rate of malposition of femoral prosthesis was 7.9% in dominant side compared with 20.8% in non-dominant side. The difference between the two groups was statistically significant ($\chi^2=5.083$, $P=0.024$). There was statistically significant difference between the sides for malposition of femoral component.

Total operative time between the sides

The total operative time of the dominant side was (111.8±26.9) min, and the non-dominant side was (113.7±26.1) min. The mean operative time of TKA in the dominant side was shorter than that of the non-dominant side, but the difference between the sides was not statistically significant. ($t=-0.422$, $P=0.674$).

Discussion

Our study suggests that there was a significant difference on the sagittal alignment of femoral prosthesis between dominant and non-dominant side TKAs performed by right-handed surgeons. Several studies about the influence of surgeon's handedness have been reported in total hip arthroplasty (THA). Song et al.¹⁵ evaluated the placement of postoperative acetabular prosthesis and found that the right-handed surgeons put the acetabular cup more ideal and accurate in right THA than in left THA. They hypothesized that it is more comfortable and convenient for a right-handed surgeon to operate right THA than on the opposite side. Similarly, when the right-handed surgeons performed TKAs, they also faced the problem of the dominant and the non-dominant sides. At present, there are few studies on the relationship between the surgeon's dominant side and the position of the prostheses after primary total knee arthroplasty.

In Mehta et al.'s¹⁶ study, they found that there were statistical differences in extension and KS Function and Pain scores in patients who underwent TKAs performed by a right-handed surgeon standing on the side of the operative extremity. They thought this may be related to dexterity or proprioception and should considerate laterality of operative site with respect to surgeon handedness as a factor affecting task performance and outcome. Our study suggested that the malposition rate of sagittal femoral prosthesis in non-dominant side was significantly higher than dominant side. Sagittal plane positioning and alignment of the femoral component were associated with anterior knee pain according to Scott CEH et al's study¹⁷. However, Hsieh et al.¹⁸ retrospectively analyzed 233 patients accepting primary total knee arthroplasty and found that there was no statistical difference in the bony procedures of tibial resection and femoral cutting between left and right TKA performed by right-handed surgeons. In addition, the thicknesses of the polyethylene were not significantly difference between two groups. They concluded that the right-handed orthopedic surgeons successfully performed TKA procedures to achieve bone resection, soft-tissue balance and thicknesses of the polyethylene between left and right extremity.

But we studied the placement angles of component by comparing the postoperative coronal and sagittal alignment of knee prosthesis in left and right side and might better reflect the operation of surgeons in TKA.

At present, the reasons for the different effects of right-handed surgeons performed on left and right side are not clear. But we have posed a possible hypothesis. In our study, all patients who accepted primary TKA were placed in supine position. During right TKA, the right-handed surgeons often choose entry point by holding the drill with their right hands. However, the entry point was chosen by right-handed surgeons with their left hand in left TKA for convenience. In these cases, the positions of the entry point in left TKA are higher or lower than right TKA. This difference of entry points in left and right TKAs may result in malposition of femoral prosthesis in sagittal. In addition, we found no significant differences of total operative time between the two sides.

This study has several limitations: (1) This is a retrospective and single-center study, which may have uncontrolled confounding factors which can result in marked bias. (2) All parameters were measured on X-ray films and no measurement of implant rotation. (3) Three surgeons included in our study were right-handers, which probably results in one-sidedness of the result. Further research would be conducted to eliminate the above limitations.

Conclusion

The results of this study suggest that surgeon handedness is likely to be one of factors that affects the placement of femoral component, especially with regard to the postoperative sagittal alignment of the femoral component. The placement of femoral component performed by the dominant hands of surgeons is more accurate than that performed by the non-dominant sides. The rate of malposition of femoral prostheses in the non-dominant side is higher than that in the dominant side. Orthopaedic surgeons should be aware of the potential problems that may be introduced by their handedness and the laterality of operated extremities and consider taking extra precautions to mitigate the risk before performing surgery.

Abbreviations

TKA: total knee arthroplasty; HKA: hip-knee-ankle angle; PDFA: posterior distal femur angle; PPTA: posterior proximal tibia angle; mLDFA: mechanical lateral distal femoral angle; mMPPTA: mechanical medial proximal tibial angle; PACS: picture archiving and communication system; BMI: body mass index; ICC: interclass correlation coefficient; THA: total hip arthroplasty.

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Authors' contributions

FCZ performed the study, analyzed the data, and wrote the manuscript. GJY and SZX helped in the revising of the manuscript. LZ, GCZ and DDL helped in the collecting of the data. LL was involved in the study design, and made meaningful suggestions. All authors reviewed and approved the final submitted version.

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Availability of data and materials

All data generated or analyzed during this study are included in this published article. We do not

wish to share our patients' data because it involves patient's privacy.

Ethics approval and consent to participate

This study has been approved by the Ethic Committee of the Affiliated Hospital of Xuzhou Medical University (NO.XYFY2019-KL111-02). Informed consent was obtained from all patients included in the study.

Consent for publication

We obtained permission from patients to publish their data, and all authors consent for publication.

Competing interests

The authors declare that they have no competing interests.

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Appendix

Fig2.1 Method for measuring HKA,mLDFA and mMPPTA on the full radiography

Fig2.2 Method for measuring PDFA and PPTA on the lateral radiographs

Fig.3 The percentage of safe zone placement for knee prostheses and both for dominant and non-dominant side TKA in surgeon A,B,C and all patients

Table 1 Characteristics of patients and knee prostheses

Item	Dominant side	Non-dominant side	t/ χ^2	P Value
Age (years)	68.3±6.5	66.3±7.7	1.743	0.083
Gender (male/female)	16/60	11/61	0.827	0.363
BMI (kg/m ²)	26.4±3.3	26.8±4.4	-0.710	0.479
Preoperative HKA	6.7±10.1	9.4±8.7	-1.733	0.085
Diagnosis, (n,%)	-	-	0.829	0.661
Osteoarthritis	73(49.3%)	67(45.3%)	-	-
Rheumatoid arthritis	2(1.4%)	4(2.7%)	-	-
Traumatic arthritis	1(0.7%)	1(0.7)	-	-
Prosthesis type, (n,%)	-	-	2.329	0.676
Zimmer Nex Gen LPS	25(16.9%)	22(14.9%)	-	-
LINK Gemini PS	20(13.5%)	23(15.5%)	-	-
Depuy PFC Sigma	15(10.1%)	14(9.5%)	-	-
AK-JPX(China)	15(10.1%)	10(6.8%)	-	-
GKPS(China)	1(0.7%)	3(2.0%)	-	-

Abbreviations: n number, BMI body mass index, HKA hip-knee-ankle angle

Table 2 The preoperative index in dominant and non-dominant side

Groups	age (years)	Gender		BMI (kg/m ²)	HKA (°)	mMPTA (°)	mLDFA (°)
		male	female				
Dominant (n=76)	68.3±6.5	16	60	26.4±3.3	6.7±10.1	85.2±4.1	91.4±4.1
Non-dominant (n=72)	66.3±7.7	11	61	26.8±4.4	9.4±8.7	84.8±5.2	90.3±4.0
<i>t</i>	1.743	$\chi^2=0.827$		-0.710*	-1.733	0.552	1.710
<i>P</i>	0.083	0.363		0.479*	0.085	0.582	0.089

Table 3 The post-operative data in dominant and non-dominant side

Groups	n (knee)	HKA	mLDFA	mMPTA	PDFA	PPTA
Dominant	76	2.1±4.2	88.7±2.7	89.5±2.7	90.2±3.3	84.8±2.8
Non-dominant	72	1.6±4.1	89.0±2.8	89.9±2.7	88.8±3.6	85.4±3.7
<i>t</i>	-	0.804	-0.564	-1.011	2.471	-1.090
<i>P</i>	-	0.423	0.574	0.314	0.015	0.278

Figures

Figure 1

Study details TKA=total knee arthroplasty, CR-cruciate-retaining

Figure 2

2.1 Method for measuring HKA,mLDFA and mMPTA on the full radiography. 2.2 Method for measuring PDFA and PPTA on the lateral radiographs

Figure 3

Fig.3 The percentage of safe zone placement for knee prostheses and both for dominant and non dominant side TKA in surgeon A,B,C and all patients